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Key animal welfare issues in commercially-raised dairy calves: social environment, nutrition, and painful procedures

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DECLARATION OF INTEREST

The authors do not claim a conflict of interest.

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ABSTRACT

Dairy calf welfare concerns are growing and new evidence suggests that the early life environment influences appropriate physical, behavioral, and cognitive development lasting into adulthood. This review highlights key evidence for the impacts of housing, diets, and painful procedures on calf welfare. We argue that these topics are currently critical welfare concerns, but are not the only points of concern. In addition to environmental requirements to maintain optimal health, dairy calves experience other challenges including social and nutritional restrictions. Individual housing is associated with impaired behavioral development and cognitive ability. Pair- and group-housing can mitigate some of these negative effects and should be encouraged. Restrictive milk allowances (< 15% of body weight) leads to poor growth and hunger; these welfare concerns can be addressed with proper enhanced milk allowances and gradual weaning programs. Finally, dehorning is a critical animal welfare issue when pain control is withheld; calves show negative behavioral, physiological, and emotional responses during and after dehorning. The combined use of local anaesthetics and analgesics can mitigate these effects. An industry shift toward providing social companionship, enhanced milk allowances, and pain control during painful procedures would help to improve the welfare of dairy calves in intensive commercial rearing facilities.

Keywords: individual housing, group housing, heifers, dehorning, weaning
INTRODUCTION

Raising healthy replacement dairy heifers is critical for the success of the future dairy herd. Concern for animal welfare is not new in the dairy industry (for an in-depth review, see Rushen et al., 2007 and von Keyserlingk et al., 2009), and in recent years there has been growing attention toward dairy youngstock (reviewed by Costa et al., 2016). The last decades have seen many changes in the dairy industry, especially affecting health and welfare of cattle, and much of it is supported by a myriad of scientific evidence (Barkema et al., 2015; von Keyserlingk and Weary, 2017); moving forward, there will be increasing emphasis on the management and welfare of youngstock.

Dairy calf health and environmental needs, such as colostrum management, ventilation, and heat stress alleviation have been the focal points of many reviews (e.g. Besser et al., 1994; Roland et al., 2016; McGuirk, 2008; Lorenz et al., 2011); these are important contributing factors to dairy calf welfare that focus on the biological functioning as reflecting animal welfare. This review will not focus on these topics, but rather on other aspects of welfare. One of the most prevalent animal welfare concerns regarding the care of production animals is regarding the potential inability of animals to satisfy a motivation to perform natural behaviors in intensive farming systems (Fraser et al, 2008). Indeed, it was the lack of ‘naturalness’ in production systems that drew the public’s attention toward the use of restricted housing systems such as battery cages, crates and gestation stalls in Ruth Harrison’s seminal work Animal Machines (Harrison, 1966). The ability of animals to express their natural behaviors remains a significant animal welfare concern today. For example, when Brazilian city-based consumers were informed of zero grazing practices and cow-calf removal as standards in the dairy industry, consumers rejected the practice, citing lack of “naturalness” as a main contributor to their reasoning (Hötzel et al., 2017). Additionally, Canadians cited natural behavior (pasture access, no cow-calf
removal) as animal welfare issues, and after touring a medium sized dairy farm in British Columbia, 33% had a negative impression after seeing cows did not have pasture access and cow-calf removal was common practice (Ventura et al., 2016). In fact, the provision of naturalness, and optimal animal welfare, was found to be associated with “safer food” and was the largest impact factor for British consumer’s purchasing decisions for organic foods (Harper and Makatouni, 2002). Therefore, optimizing dairy cattle welfare should include factors associated with their evolutionary background. This includes behaviors such as grazing and mothering, and the natural behavioral repertoire of dairy calves including suckling milk from a teat and socializing with other calves in the herd; however, many dairy calves in commercial production systems around the world are limited or prevented to perform these behaviors. These practices evoke animal welfare concerns regarding the prevention of behaviors that animals are intrinsically motivated to perform (i.e. their behavioral needs), and negative affective states, such as frustration, may arise as a result of these restrictions (reviewed by Mandel et al., 2016). For example, repeated inability to express a natural behavior often leads to development of abnormal behaviors; dairy calves who are not provided a teat for suckling are more likely to suck on other calves, and perform more non-nutritive oral behaviors (Mason and Burn, 2011; Ninomiya, 2014). Therefore, permitting the expression of natural behaviors in dairy calves may also potentially reduce frustration and expression of abnormal behaviors.

Another important welfare consideration is minimizing an animals’ negative emotional state like pain, fear or frustration, and providing opportunities for animals to experience positive emotional states; both are typically a major focus and determinant of good animal welfare and have even been described as the most important consideration for which we should be measuring an animal’s welfare (Duncan, 1996). The scientific ability to objectively measure emotional
states has been met with criticism, but in recent years we have made significant advancements in the study of emotional states of farm animals, especially around the topics of pain assessment and control (Weary et al., 2006) and some aspects of positive emotional states (Boissy et al., 2007).

Questions regarding the management and care of production animals must also include an understanding of the views and attitudes of the public as an important stakeholder in the dairy industry. For instance, the public has expressed concern regarding practices such as dehorning of calves without pain control (Ventura et al., 2015), cow-calf separation at birth (Ventura et al., 2013) and limited or no pasture access (Schuppli et al., 2014; Hötzel et al., 2017). This disconnect between the public perception of and expectations for dairy management practices puts the sustainability of the dairy industry at risk (von Keyserlingk et al., 2013).

Therefore, the aim of this review is to highlight three of the key animal welfare concerns facing the dairy industry, particularly regarding dairy calf management practices. We also discuss possible solutions that are expected to improve the welfare of dairy calves, and consequently may address potential concerns from the public. Because of their importance and high prevalence on dairy farms we have selected the calf management issues of restricted social housing (i.e. individual housing), restricted nutrition, and painful procedures (where dehorning will be used as focal topic) for this review, although we understand there are other management practices that also hold animal welfare concern. These topics were selected on the basis of the three general ethical concerns for an animal’s quality of life outlined by Fraser et al., (1997), including a calf’s ability to express its natural behaviors, achieving optimal biological functioning, and minimizing negative emotional states if best management practices are not performed.
EARLY LIFE RESTRICTED SOCIAL HOUSING

Natural social environment of calves

To understand the natural behaviour of a dairy calf (and therefore its behavioural needs in commercial rearing systems), we need to understand its evolutionary environment and natural behaviour repertoire. Opportunities to study feral cattle populations are limited, and direct ancestors such as the Auroch are extinct (Decker et al., 2014); however, the Chillingham cattle population has been isolated from human management for 700 years and is considered to live in a natural environment (Bouissou, 2001). The social environment of calves in natural and semi-natural environments is a complex one (reviewed by Cantor et al., 2019). Briefly, in free-ranging herds, the dam delivers her calf in seclusion from the herd and the offspring remains hidden during the first few days of life; it has been suggested that appropriate selection of the birthing site influences a cow’s success in bonding with her calf (reviewed by Rørvang et al., 2018). After calving, maternal behaviors exhibited by the dam include licking, specific vocalizations, and allowing the calf to suckle (Von Keyserlingk and Weary, 2007). It has been theorized that the cow-calf relationship is only partially nutritionally dependent (Johnsen et al., 2015). Research has shown that calves permitted to access their dam only at night, and allowed to drink from automatic milk feeders, resulted in most cow-calf pairs rejoining within 3 min, with allogrooming exchanges among cow-calf pairs (Johnsen et al., 2015; Johnsen et al., 2018). Therefore, the bond between cow and calf is likely a combination of olfactory cues, grooming, and suckling.

Following birth, the calf and dam re-integrate into the herd, though the age at which re-integration occurs varies from approximately 1 wk (Bouissou et al., 2001) to as late as 2 wk
Crèche groups are formed, often by social facilitation of the dam after reintegration (Sato et al., 1987), but the age at which crèche groups form varies, beginning as early as 2 wk of age (Vitale et al., 1986; Sato et al., 1987). At this time, the calf gradually increases its distance from the dam, though the dam-calf bond is maintained into adulthood (Reinhardt et al., 1986; Vitale et al., 1986; Sato et al., 1987). As noted by Boissou et al. (2001), individuals still have preferential contact with their dams, even if she has since given birth to a new calf. Free-ranged calves will begin to interact with older cows, including adolescents and adults without newborn calves (e.g. Sato et al., 1987; Murphey et al., 1990). Indeed, calves that have nightly access to the dam will exchange allogrooming, and even nurse other dams in a commercial dairy setting (Johnsen et al., 2015). Calves learn appropriate social dynamics from other peers, and engage in social play such as fighting, galloping, bucking and kicking as early as two weeks of age (Reinhardt and Viktor, 1982). Play behaviors are considered a welfare indicator in animals. In many mammals, play is hypothesized to promote locomotive skill and emotional development (Spinka et al., 2001). Therefore, play behaviors in calves can be considered an expression of a natural behavior that may influence locomotor development. In summary, calves in natural conditions develop lasting social relationships with the dam and other conspecifics and engage in social behavior at a young age. We suggest that providing peers to calves from a young age promotes expression of natural social behaviors and improves calf welfare.

**Social environment of commercially-reared calves**

Commercially-reared calves are typically raised in a fundamentally different manner from the semi-natural environment. The majority of dairy cattle facilities are not designed to
accommodate cow-calf pairs for many reasons (reviewed in Johnsen et al., 2016). However, some dairy systems have recently shifted toward leaving the calf with the dam, or providing foster dams for calves (Pieper et al., 2014). This review will focus on systems that separate calves at a very young age from their dam. The majority of producers around the world remove calves from the dam and house calves individually until weaning. According to dairy producer reported surveys, 60% of farms individually raise pre-weaned calves in western and central Europe (Marcé et al., 2010), 63% in the United States (USDA, 2016), 88% in Quebec, Canada (Vasseur et al., 2010), and approximately 70% in Brazil (Glauber Dos and Carla Maris Machado, 2015). One rationale for the immediate separation of calf and dam is to prevent the transmission of diseases, such as Johne’s disease (Mycobacterium avium spp. Paratuberculosis), which is spread by contact with an infected animals’ manure, blood, or milk (National Research Council Committee on Diagnosis and Control of et al., 2003). An additional reason for separating the calf from the dam is to ensure the calf receives high quality colostrum in a timely manner and adequate passive transfer (reviewed by Henderiana, 2009). However, due to a calf’s naïve immune system, calves are highly susceptible to disease, with manure-transmitted pathogens often being a cause of diarrhoea. Therefore, in conventional systems, calves are usually placed in individual housing in consideration of long-term health and functioning for the mature animal’s welfare.

What is the welfare issue?

The practice of individual housing in early life is among the most recognized welfare issues in dairy calves, and its importance is underscored by the wealth of literature demonstrating the detrimental effects of restricted social housing (limited or no contact with other peers) in
other species. Infancy is one of the most sensitive periods of development for mammals, with the environment playing a crucial role in development (Bornstein, 1989). The detrimental effects of maternal separation and social isolation during infancy have been studied in a range of social species, especially rodents (Grippo et al., 2008), primates (Harlow, 1959) and humans (Buzzell et al., 2018). Numerous negative effects of social deprivation have been identified, including abnormal behavior and other developmental problems, such as impaired maternal care (Lovic et al., 2011), increased aggression (Tulogdi et al., 2012) and impaired social recognition (Tulogdi et al., 2012). Farmed mammals (e.g. sheep, pigs, horses and beef cattle) are typically housed together with their dam during the milk-feeding period. In these cases, the young normally also have contact with siblings and conspecifics of similar age, where dairy cattle production is the exception.

Dairy calves are highly motivated to have social contact in early life, and spend on average about 2% of their time engaged in social contact during the first 8 wk of life (Chua et al., 2002). In an operant response task, calves worked to gain access to a familiar calf, and worked harder to have full social contact than to limited social contact across a barrier (Holm et al., 2002). Beyond this intrinsic motivation for social contact, there is growing evidence showing the benefits of socially housing calves in pairs, groups or with their dams compared to individual housing (Costa et al., 2016). In particular, social housing is crucial for the development of normal social behavior, and is dependent on factors such as age of first contact and level of interaction with conspecifics. Compared to calves housed individually or with limited contact with conspecifics, socially-housed calves are less fearful (Jensen and Larsen, 2014), perform better in a cognitive test (Gaillard et al., 2014) and have increased competitive success at the feed bunk (Duve and Jensen, 2011). Social companions have also been shown to be beneficial during
acute stress. Social support is the ability of social partners to decrease the impact of stressors during a challenge (Cohen and Wills, 1985), and has been demonstrated in other farm animal species (Rault, 2012), including cows and calves (e.g. Boissy and Le Neindre, 1997; Piller et al., 1999; Færevik et al., 2006; de Paula Vieira et al., 2010).

Another benefit of social housing that is less often discussed is the opportunity for calves to develop social relationships with others. This topic is gaining increased attention given its fundamental importance for gregarious animals (Rault, 2018). The benefits of socially versus individually-housing calves has been attributed to the formation of social relationships and the opportunity for calves to learn social and problem-solving skills (Jensen et al., 2015). Calves are known to prefer familiar conspecifics (Duve and Jensen, 2011) and early separation of calf and dam may strengthen the bond between calves that are subsequently reared together (Bøe and Færevik, 2003). Thus the relationships between calves may be especially strong in calf-rearing systems, and these early life social bonds seem to endure (Færevik et al., 2006). We discuss some of the evidence that calves may develop social bonds and the implications of this for how we manage calves.

**Affiliative relationships**

Evidence for the existence of affiliative relationships is found in the structure of cattle herds. Matriarchal relationships alone cannot account for cow-groupings in free-ranging herds, since preferred partners are not always close relatives (Reinhardt and Reinhardt, 1981). Moreover, social relationships in animal groups have been characterized by socio-negative interactions leading to dominance hierarchies (e.g. De Vries, 1998), as well as socio-positive interactions that help explain accounts of preferential performance of behaviors with certain
individuals of a herd (e.g. Reinhardt and Reinhardt, 1981). In managed herds, behavioral expression of social licking, play, and responses to isolation provide evidence that calves have social bonds (reviewed by Boissou et al., 2001).

Social licking is recognized as one of the most significant behaviors in the maintenance of social bonds (Von Keyserlingk et al., 2008). The terms “social licking” and “allogrooming” are often used interchangeably to describe this behavior in which an individual’s tongue is in contact with any part of the body of another individual and accompanied by repetitive licking. This behavior has been noted in both semi-wild cattle (Reinhardt and Reinhardt, 1981) and herds in intensive production systems. Indeed, research has shown cattle increase allogrooming behaviors during social changes such as re-grouping (Von Keyserlingk et al., 2008) and when housed in closer proximity (freestalls) versus on pasture (Tresoldi et al., 2015). Allogrooming begins as soon as a calf is born; in addition, research has shown that calves reared by the dam perform more allogrooming than calves raised individually (Wagner et al., 2012). This is also true for cow-calf pairs provided nightly access to one another, regardless if the calf had access to supplementary milk from an automatic feeder during the day (Johnsen et al., 2015), or was prevented from nursing from the cow with an udder net (Johnsen et al., 2018). Since calves are removed from the dam within a few days and often housed individually, allogrooming opportunities with peers are expected to be minimized. Some research has shown that the provision of a brush can promote grooming behavior in pair- or group-housing environments, with up to 30 min of daily use (e.g. (Zobel et al., 2017; Falk et al., 2018) and group housed calves provided access to a mechanical brush will consistently use it with increasing age (Horvath and Miller-Cushon, 2019). In addition, individually-housed calves will also spend time with a brush demonstrating a motivation to allogroom, even without a social companion.
(Pempek et al., 2017). This work suggests that providing a grooming device to conventionally raised calves allows for the opportunity to express this natural grooming behavior.

There is also evidence that calves may develop preferential social relationships, as opposed to relationships with unfamiliar calves. When separated from the group with a familiar calf, calves vocalized less and explored the arena more than when separated with an unfamiliar calf (Færevik et al., 2006). Calves raised in pairs spent more time licking and sniffing each other when reunited after separation compared to an individually-raised calf (Duve and Jensen, 2011). This provides some indication that calves may develop preferences for familiar individuals. Perhaps calves that spend more time together have the opportunity to perform more affiliative behaviors, contributing to the formation of affiliative relationships.

Calves will also engage in social play which is considered an important social behavior to maintain social relationships in other animals (Panksepp et al., 1984; Trezza et al., 2011). However social play behaviors cannot be performed in individually housed calves, although individually housed calves are known to engage in some locomotor play when given the chance (Jensen and Kyhn, 2000). However, when individually housed calves are provided an open space they show increased locomotor play, which is hypothesized to reflect a rebound behavior for calves housed in small pens (Jensen and Kyhn, 2000). To test the effect of whether motivation for play behavior builds up over time, calves were pair then individually housed, all calves received two days of 45-minute access to an arena, then calves were deprived of arena access for 4 or 0 days; calves provided the arena after deprivation for 4 days engaged in more locomotor play than calves that were never restricted from arena access (Bertelsen and Jensen, 2019). Spontaneous play behavior is more often seen in calves housed in groups compared with individually housed calves (Valníčková et al., 2015). Calves raised together also show more play
(both locomotor and social play) when given fresh bedding compared to calves housed alone (Duve et al., 2012), and calves who were pair-housed and fed more milk (8 versus 5 L/d) played more often and had higher weight gains than calves housed individually (Jensen et al., 2015). These studies suggest that the provision of a social companion and access to space can promote play behaviors, which are suggested to increase positive affective states (Ahloy-Dallaire et al., 2019). Indeed, the positive affective states arising from play may in turn serve to strengthen social relationships among peers, although this has yet to be investigated in dairy calves.

In summary, there is growing evidence indicating that the early social environment of calves is critical for early behavioral development. Individual housing of calves limits or prevents contact with other conspecifics, which goes against the natural evolutionary biology of cattle and has been shown to have significant detrimental consequences. Thus, dairy calves should be raised with the possibility of full contact with other conspecifics (e.g. pair or group housing) that allows calves to perform social behaviors, such as allogrooming, which potentially serves to maintain social relationships. In addition, group housing provides space for calves to express locomotor play behavior, and calves restricted from locomotor play appear to be be motivated to perform this behavior over time. Therefore, in addition to social companionship, calves should be provided greater space allowances that allow them to express natural play behaviors. Affiliative behaviors, and by extension affiliative relationships, among calves facilitate the development of essential skills and provide a foundation for social support.

RESTRICTIVE DIETS

Natural nutritional environment of calves
After birth, the cow will hide her calf from the herd and feed the calf 8 to 12 times per day (Lidfors and Jensen, 1988), although there is considerable variation in the number of suckling bouts by cow-calf pair (Vitale et al., 1986). The calf depends on the dam during the first weeks of life, but social learning becomes critical as the calf ages (reviewed by Costa et al., 2016). The young calf learns to graze within the first few weeks of life by observing other herd members (Mirza and Provenza, 1994) and selects feedstuffs based on the choices of other herd mates (Provenza and Balph, 1987; Provenza et al., 2003). In addition to learning appropriate feeding behaviour patterns, the young animal learns important skills of what, when and how to safely consume feed in the environment (reviewed by Costa et al., 2016). Weaning occurs over several weeks and ends between 6 and 10 months of age (Reinhardt and Reinhardt, 1981; Weary, 2001), through a combination of reduced milk availability, increased intake of forage by the calf, and an increase in suckling bouts that are terminated by the dam (Reinhardt and Reinhardt, 1981). Weaning is also accompanied by increased social interactions with other calves (Boissou et al., 2001), likely facilitated by decreased dependence on maternal care.

**Nutritional environment of commercially-reared calves**

In conventional commercial dairy systems, calves are fed milk (either whole milk or milk replacer) 2 to 3 times per day, and most dairy producers around the world will feed 6 L or less in two meals per day (e.g. Marcé et al., 2010; Vasseur et al., 2010; Hötzel et al., 2014; USDA, 2016). This milk allowance equates to limiting the calf’s milk diet to under 15% of body weight, and also limits available nutrients for growth especially under immune challenge or temperature stress (NRC, 2001). One argument for milk restriction is the increased rearing costs associated with feeding additional meals, from once or twice per day feedings. Research has shown it
requires more labour to feed calves additional milk meals than offering more milk to calves from an automated milk feeder (e.g. Kung et al., 1997). Additionally, limiting calves on milk promotes a younger weaning age, since the restricted nutrient supply leads to greater solid feed intake at an earlier age (reviewed by Kertz et al., 2017).

**What is the welfare issue?**

There is evidence that calves receiving 4 to 6 L/d of milk experience hunger and limited growth, which is an obvious welfare challenge for dairy operations. Calves limited to 5 L/d of milk vocalized 30 times per day compared to 8 L/d calves who vocalized 5 times per day (Thomas et al., 2001). In group housing, unrewarded visits to the milk feeder (not permitted milk after the full milk allowance has been consumed) has been suggested as a sign of hunger (Jensen and Holm, 2003; de Paula Vieira et al., 2008); calves permitted 6 L/d of milk had higher frequencies of unrewarded visits and less growth when compared to calves allotted 8 or 12 L/d (Rosenberger et al., 2017). This research suggests vocalizations and unrewarded visits to the milk feeder are a sign of hunger, and calves limited to conventional milk allowances are motivated to access more milk.

An obvious solution to the welfare issue of restricted milk diets is to feed a higher allowance of milk. There are a growing number of studies showing the benefits of feeding a higher plane of nutrition to calves (e.g. Appleby et al., 2001; Diaz et al., 2001; Kiezebrink et al., 2015; reviewed by Khan et al., 2011). For example, calves fed more milk have greater growth during the milk-feeding period, especially when fed 10 L/d of milk or more compared to calves fed 6 or 8 L/d of milk (Rosenberger et al., 2017). In addition, feeding higher planes of nutrition to calves may enhance mammary development (Geiger et al., 2016), and improve first lactation
milk yield compared to calves fed a restricted plane of nutrition (Gelsinger et al., 2016). However, there are several main criticisms of feeding higher milk allowances to calves; with these criticisms in mind, we will focus our discussion on how management practices can be modified to optimize calf welfare and behaviour by feeding higher planes of nutrition pre-weaning.

One criticism of feeding additional milk is that calves do not appropriately transition to solid feed in a timely manner, leading to compensatory growth in limit-fed calves. Research has shown that a milk replacer (25% crude protein, 17% fat DM basis) fed at either 0.66 DM/d or 1.09 DM/d with an abrupt weaning age at 42 d, or a 1.09 DM/d with gradual weaning from 35 to 53 d leads to compensatory growth in the limited milk calves, including higher faecal digestibility than the abruptly weaned 1.09 DM/d calves. Gradually weaned calves had the best post-weaning digestibility of nutrients, though no differences in weights were found at 112 d of age (Dennis et al., 2017). This suggests that abrupt weaning of calves fed high amounts of milk affects gut preparation (i.e. impaired digestibility of nutrients). Other research has seen a similar effect when feeding more milk. For example, calves consuming 1.35 DM/d of milk replacer (12 L/d) and gradually weaned from day 36 to day 48 had higher volatile fatty acids and greater faecal starch digestibility than abruptly weaned calves (Steele et al., 2017). This is likely because calves that are gradually removed from milk have an opportunity to increase their solid feed intake before complete milk removal (Sweeney et al., 2010). Together this work suggests that calves fed more milk should follow a gradual weaning program to promote gut preparation and nutrient digestibility post-weaning.

A potential solution to the issue of encouraging solid feed intake in calves that are fed high amounts of milk is to implement an initial milk reduction after 4 to 5 wk which stimulates
earlier intake of grain in calves fed 10 or 12 L/d of milk (e.g. Rosenberger et al., 2017). Automated weaning based on each individual’s solid feed intake has also proven to be successful for many calves, but some calves still struggle to complete the weaning transition (Benetton et al., 2019). Recent work has also shown that individual characteristics, such as exploratory personality traits, are related to feed intake and growth of calves during weaning (Neave et al., 2018), suggesting that there is considerable opportunity to tailor early nutrition and weaning management to the individual’s needs.

Abnormal oral behaviours are another animal welfare concern in dairy calves. Calves that are fed limited amounts of milk, or fed from a bucket instead of a nipple, show abnormal oral behaviours directed toward sucking of fixtures in the pen or cross-sucking other calves (reviewed by Jensen, 2003). Thus, feeding higher amounts of milk from a teat can significantly reduce these behaviours. Access to forage such as hay can also address abnormal oral behaviours; research has shown that feeding calves 6 L/d of milk replacer by teat with hay access resulted in fewer non-nutritive oral behaviours directed at the pen compared to calves fed by teat without hay access, and calves fed by bucket without hay access (Horvath and Miller-Cushon, 2017). Forage access has other potential benefits (reviewed by Khan et al., 2011b, a), particularly for calves receiving higher milk allowances (Khan et al., 2011a). However further research is required to elucidate the potential benefits of forage feeding and the causes of it.

In summary, research suggests feeding calves higher planes of nutrition can improve growth and reduce hunger when calves are gradually weaned compared to calves fed restricted amounts of milk. Since farms are growing in size and implementing precision dairy technologies for individual-based and data-driven decisions (reviewed by Rutten et al., 2013; González et al., 2018), the dairy industry has an opportunity to focus on individualized calf management to
improve welfare. For instance, farms can capitalize on individual variability in how quickly calves begin to eat solid feed, by allocating milk away from these calves to initiate weaning and toward calves that require more time on milk before removal.

PAINFUL PROCEDURES: DEHORNING

Dehorning of dairy calves is a common farm procedure that involves prevention of horn growth by means of cauterization (hot-iron) or chemical burn (caustic paste). Dehorning is performed for the safety of farm personnel and to prevent dairy cattle from using their horns to harm one another. Dehorning methods and other factors such as calf age, product use and handler training are variable across farms (reviewed by Stafford and Mellor, 2005), and these factors will certainly contribute to the overall welfare of the calf during and after the dehorning procedure. However, this section will focus on the pain caused by the procedure given there is concern from the public about the practice of dehorning without pain control (Robbins et al., 2015; Ventura et al., 2015).

What is the welfare issue?

Veterinarians and dairy producers agree that dehorning is painful (Winder et al., 2016). There is clear evidence that this procedure causes substantial behavioral and physiological responses at the time of dehorning if no pain control is provided and can persist to at least 24 h after the procedure (reviewed by Stafford and Mellor, 2011). For instance, calves show pain-related behaviors such as head shaking, ear flicking, head rubbing, grooming, standing-lying transitions, and hind-leg kicks up to 24 h after dehorning without pain control, with peak responses occurring 4 to 6 hr after the procedure (Faulkner and Weary, 2000). Physiological
parameters show a similar pattern, with plasma cortisol concentrations rising immediately after dehorning and generally return to baseline 1 to 2 h afterwards (Grøndahl-Nielsen et al., 1999), but may remain elevated for up to 24 hr (Morisse et al., 1995). Some work has also shown that the wound remains sensitive up to 75 hr after dehorning (Mintline et al., 2013). Calves also experience an emotional response to dehorning, showing a negative judgement bias indicating pessimism and a low mood up to 22 h after dehorning compared to before (Neave et al., 2013; Daros et al., 2014). Most recently it has been shown that dehorned calves avoided an area where they experienced dehorning compared an area where they experienced sedation alone (Ede et al., 2019), indicating that dehorning is aversive to calves.

An obvious way to address the welfare concern around painful practices is to provide pain mitigation. In North America, dehorning is often performed without pain control such as a local anaesthetic or non-steroidal anti-inflammatory (NSAID), with 15 to 45% reporting using a local anaesthetic and less than 2% (or none reported) using an NSAID (Fulwider et al., 2008; Misch et al., 2007; Vasseur et al., 2010). However, in the last decade, this practice seems to be changing in Canada, where 62% and 25% of producers reported using a local anaesthetic and NSAID, respectively (Winder et al., 2016).

A recent systematic review and meta-analysis of the effects of local anaesthetics and analgesics on pain from dehorning supports the combined use of both pain control methods to reduce behavioral (ear flicks, head shakes), physiological (plasma cortisol), and wound sensitivity following cautery dehorning (Winder et al., 2018). A sedative, such as xylazine, is sometimes used prior to dehorning to reduce activity and facilitate handling of calves; however, this inactivity should not be interpreted as effective pain control since xylazine provides only mild analgesia. For example, Stilwell et al. (2010) showed that calves treated only with xylazine
had a greater degree of struggling during the procedure, and more pain-related behaviors after
dehorning, compared to calves that also received a local anaesthetic. Grøndahl-Nielsen (1999)
showed xylazine-sedation alone only slightly reduced the number of head jerks during dehorning
compared to control calves. The use of sedation in Canada is reported by 38% of producers,
citing reduced handling stress and ease of handling as reasons for its use in dehorning calves
(Winder et al., 2016).

A cornual nerve block with a local anesthetic such as lidocaine provides short-term pain
relief for 2 to 3 h after dehorning. Although this offers an initial protective effect, plasma cortisol
concentrations return to peak level after the anaesthetic wears off (reviewed in Winder et al.,
2018). This indicates pain responses are delayed rather than prevented when given a local
anaesthetic, but administration at least offers some benefits for the animal at the time of
dehorning. However, there is less consensus among studies on the protective effects of a local
anaesthetic alone on pain-related behaviors such as head shakes (e.g. Stilwell et al., 2010, 2012;
Graf and Senn, 1999).

Analgesics, such as NSAIDs, offer post-operative pain relief for a longer duration, up to
24 h after dehorning. There is strong evidence that analgesics when provided in conjunction with
a local anaesthetic provide effective pain relief up to 24 h compared to only a local anaesthetic.
An NSAID such as meloxicam or ketoprofen mitigated the rise in plasma cortisol concentrations
after the duration of the local anaesthetic, and also reduced pain-related behaviors such as ear
flicks, head shakes and head rubs, and reduced wound sensitivity, especially in the 3 to 6 h after
dehorning (reviewed in Winder et al., 2018). Other work has also shown that meloxicam-treated
calves spent more time at the feed bunk and spent more time lying down compared to control
calves (Theurer et al., 2012). Overall, the provision of an analgesic in combination with a local
anaesthetic is the most effective method of pain control following cauterization dehorning and should be considered best practice, since it treats both short- and long-term pain. However, there is little understanding of how long calves experience the pain from dehorning; it may be that administration of an NSAID labeled for efficacy up to 24 h is insufficient.

Another opportunity to address this welfare concern of painful dehorning practices is to use polled genetics. Horns are a recessive trait in cattle, requiring both parents to have a horned gene to continue the trait (Stella et al., 2010). Therefore, selection of sires with polled genetics eliminates the need to dehorn calves. As consumer pressure increases regarding the need to eliminate the dehorning procedure, the use of polled genetics is a large opportunity for the dairy industry to address this welfare concern.

In summary, calves experience substantial short- and long-term pain when dehorned; best practice should be the provision of a local anesthetic and analgesic for pain control. While producers have improved their use of pain medication, there is a need to promote increased use of analgesics to control long-term pain. Producers should also be encouraged to incorporate polled genetics into their herds to eliminate the dehorning procedure.

CONCLUSIONS

In conclusion, there is growing evidence that dairy calves experience significant welfare challenges beyond health and environmental needs, including social and nutritional restrictions that are common practice around the world. Restricted social housing by individually-housing calves until weaning has been shown to impair behavioural development and cognitive ability. Given that calves are a social herd species, providing access to social companions can mitigate these negative effects. Social housing of calves, either by pair-housing, group housing or with
the dam and other calves promotes learning through social facilitation, social buffering of stress when presented with challenging situations, and allows for the formation of strong social bonds. Restricted nutrient intake by limiting milk allowance to under 15% of body weight leads to impaired growth and increased hunger. These welfare concerns can be addressed by increasing milk allowance and weaning calves gradually. Attention toward the natural behavioural repertoire of the calf can be beneficial, such as providing a teat rather than a bucket to permit sucking, and providing forage access can reduce abnormal oral behaviours. As dairy operations continue to implement data-driven decisions, there is opportunity to incorporate individual tailored feeding managements, such as weaning strategies, that should be explored. Finally, dehorning is a painful procedure that nearly all operations perform, making it a critical animal welfare issue when pain control is withheld. Dehorning causes behavioural, physiological, and negative emotional responses to pain, but the combined use of a local anaesthetic and analgesic can mitigate these effects.

This review has highlighted several key welfare issues facing young stock in the dairy industry. We argue that the selected topics of restricted social and nutritional environments, and painful procedures such as dehorning are currently the most prevalent welfare concerns since the majority of dairy farms employ these practices. These practices are also especially prone to criticism and increased scrutiny from the public given they limit the opportunities of calves to express their natural behaviour and invoke negative emotional states. Moving forward, we call attention toward the refinement of these practices that will manage calves in such a way that meets (and hopefully exceeds) their social and nutritional requirements, and provides best practices for pain control during dehorning.
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